THE FOSSIL COLLECTOR

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Bivalve of the family Clavagellidae, commonly known as a Watering Pot Shell (x2). Specimen found at the base of the Morgan Limestone on the left bank of the Murray River, north of Big Bend, South Australia. Photograph courtesy of Chris Ah Yee and Janise Krause.

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THE FOSSIL COLLECTORS' ASSOCIATION OF AUSTRALASIA

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Taxonomic Disclaimer

This publication is not deemed to be valid for taxonomic purposes [see article 8b in the *International Code of Zoological Nomenclature* 3rd edition 1985. Eds W. D. Ride et al].

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EDITORIAL NOTES

Firstly, I must apologise for this bulletin being issued somewhat later than usual. A new position within the company I work for meant a weeks training in Sydney then doing work between Sydney and Brisbane during the following week.

This year's two week field trip is now also finished, and I think it would be fair to say that the six of us who went on this trip (including two very good mates from Arizona, U.S.A.) had a great time. We visited fossil sites near Croydon, Normanton, Karumba, Greenvale and Cracow, all in Queensland. The ages of the material we collected ranged from Devonian, Permian, Cretaceous, Plio/Pleistocene and a very recent shell coquina at Karumba which for me was very interesting. The most memorable part of the trip (other than the fossils we collected) was watching one of the group very busily collecting sub-fossil gastropods and quickly placing them in every available pocket, only to have a multitude of hermit crabs just as quickly trying to escape from those same pockets. I never have heard a grown man squeal quite as well as I did that afternoon.

I also had the opportunity to meet Paul Kipriotis, a wonderful young gentleman from Tully (North Queensland) who would be one of the keenest amateur palaeontologists I have had the chance to meet. It was great talking to Paul about all things palaeontological, especially the discussion about primitive whales. Paul's parents also need to take a bow as well, they are supporting and encouraging Paul in his palaeontological pursuits and don't mind driving him into central Queensland to collect fossils, well done.

I would like to thank Robert Knezour, Don Eastwell and Frank Holmes for providing material for this issue of *The Fossil Collector*. Although we still do not have any major articles to print, the news stories keep on flowing in and these are interesting enough for the moment.

My family and I would like to wish all readers of *The Fossil Collector* and their families a safe and happy Christmas and enjoyable New Year.

The deadline for the next issue, Bulletin 68 will be November 31, 2002.

FINANCES

Income and expenditure for the twelve months, July 1, 2001 to June 30, 2002. The previous twelve months income and expenditure (July 1, 2000 to June 30, 2001) is shown in brackets

INCOME			EXPENDITURE		
Subscriptions			Postage	501.25	(610.86)
current	1009.50	(783.25)	Printing	562.05	(694.61)
advance	325.50	(569.00)	Photocopies,		
overpaid	—	(17.50)	photo's & bromides	13.75	(147.00)
Donations	34.50	(31.47)	Stationery	23.40	(175.98)
Advertising	—	—	Sundries	12.15	(216.28)
Bank Interest	2.01	(12.31)	Secretarial expenses	30.46	(87.65)
Sale of Bulletins	105.00	(301.00)	State/Federal tax	5.58	(5.22)
			Refunds	—	(17.50)
			Miscellaneous	—	—
	$1,476.51	(1,714.53)		$1,148.64	(1,955.10)

Balance at June 30, 2002.

Brought forward from	2000/2001	$2,289.67
Add income	2001/2002	$1,476.51
		$3,766.18
Less expenditure	2000/2001	$1,148.64
		$2,617.54

When the 2001/2002 income is adjusted to include subscriptions paid in 1999/2000 and 2000/01 ($572.50) and to exclude 2002/03 subscriptions ($325.50), income for the financial year 2001/2002 exceeded expenditure by $574.87, compared with $28.93 for the previous year. After deducting total advance subscriptions from the balance in hand at June 30, 2002, we are left with a **NET RESERVE OF $2,276.64** ($1,711.17).

Assets are valued at approximately $2,200 (these include part ownership of a word processor [50%], stationery, staplers and back issues of Bulletins etc.). At June 30, 2002, there were no liabilities.

Frank Holmes, Secretary/Treasurer

FOSSIL COLLECTING IN QUEENSLAND - AN UPDATE

Robert Knezour

Long time FCAA members may be interested to see an update on the two articles published in May 1991 and January 1992. While my interest has grown with age, I can report on a few papers generated by that early plant/insect love affair.

Triassic plant material from localities at Blackstone and Dinmore, Ipswich and the Esk Beds has been described by Gary Pattemore in his Honours Thesis "Fructifications and how they relate to the environment in the Triassic and Early Jurassic of Queensland". Included in Appendix A is a paper "An Early Jurassic Pteridosperm Fructification from Queensland" which describes the "large number of other identical fructifications" (*The Fossil Collector* May 1991, p31), as a deposit of both male and female pteridosperm fructifications from Narangba, Queensland. This paper was presented by Gary at the 10th Gondwana Symposium in Cape Town, South Africa in 1998 and later published in the *Journal of African Earth Sciences*. The fructification was named *Knezourocarpon narangbaensis*. Gary is presently working on other material from Blackstone, Dinmore, Esk and Narangba.

From the Redbank Plains locality (*The Fossil Collector* May 1991, pp33 - 34), Andrew Rozefelds, now at the Tasmanian Herbarium, published a paper in 1996, in which he describes 'eucalypt like' fruits found in 1990. Alan Rix reports similar Myrtaceae fruits in his collection (pers. comm).

'Part of the foot of an extinct bird' (*The Fossil Collector* May 1991, p34) was described by Pat Vickers-Rich and Ralph Molnar in 1996. The suggestion is that the fossil may represent the oldest known member of the dromornithid group as yet found in Australia. A colour photograph of the fossil can be seen in the book *Wildlife of Gondwana*.

T. D. Houston submitted an Honours Thesis detailing fossil insect from Redbank Plains and Dinmore. The Queensland Museum contributed specimens from both localities, Alan Rix made his Redbank Plains collection available and I donated material from Dinmore. Some new species were named including a Lower Eocene termite.

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NEW SCIENCE CENTRE IN VICTORIA

Frustration with "simplistic theme park approaches" to science museums has led to a revolutionary new Victorian centre offering visitors a hands-on science experience.

The new $4.3 million Monash Science Centre building at Monash University, Clayton, was officially opened on July 2nd. The inaugural exhibition "The History of Life in Australia - The Last 3.8 Billion Years" is one of most impressive displays of dinosaurs and other Mesozoic vertebrates in the world with a great variety of excellent reconstructions and casts. The display owes much to the enthusiasm and dedication of Professor Pat Vickers-Rich, the Foundation Director of the Centre, which has been in operation since 1992.

The emphasis of the Centre is to introduce students and the general public to science, by facilitating direct contact with research scientists in many different ways and in research scientists being involved in curriculum development at both State and Federal levels. Programs at the Centre vary from year to year but the aim is always the same - to encourage a scientifically literate public, giving them the resources to begin to make their own considered decisions about resources, medical treatment and other scientific matters that are necessary to ensure a decent future for the world.

One of the highlights of the inaugural exhibition in the new building is a glass-walled Preparation Laboratory (sponsored by the Victorian Division of the Geological Society of Australia), an interactive facility that allows geological material to be prepared in front of people who are visiting the exhibitions. The

material being prepared will change from time to time but at present Professor Rich has managed to obtain a block of siltstone, weighing several tonnes, from the Triassic of New Mexico which contains the partially articulated remains of one of the most primitive dinosaurs known, *Coelophysis*. In a cooperative program between the Monash Science Centre and the Carnegie Museum of Natural History, Pittsburgh, U.S.A., the block will remain in Australia and any new taxa found will be worked on jointly and returned to the Carnegie. All the *Coelophysis* material (more than 5 skeletons) will remain in Australia.

Anyone interested in becoming a Friend of the Monash Science Centre should contact Jenny Monaghan at Monash Science Centre, PO Box 74, Monash University, Vic, 3800, Australia. Tel/Fax (03) 9905 1370 or Email: jenny.monaghan@sci.monash.edu.au

Being a Friend of the Monash Science Centre gives you access to a range of great value opportunities including free admission, 2 free "Guest Lecture" passes, discount on shop and café purchases and a free subscription to their newsletter etc.

Web site - www.sci.monash.edu.au/msc

Information from AAP report, The Victorian Geologist (August 2002) and MSC Friends Programme pamphlet.

IN THE NEWS

Researchers Rethink Dinosaur Die Off Scenario

Dinosaurs may not have been killed off by asteroid impact dust blocking out sunlight, a geologist says. Instead, the mass extinction associated with an asteroid impact 65 million years ago might have been caused by soot from global wildfires or sulfuric acid clouds that were a consequence of the collision.

Whether ash, soot, or acid clouds from the impact, what difference does it make how the dinosaurs and other life forms died in the mass extinction event? "It probably doesn't seem important what mechanism was triggered; either way it still seems that the impact caused the extinction," says Kevin Pope from Geo Eco Arc Research in Aquasco, Maryland USA. "But the difference is important because it may have implications for the predictions of the consequences of future asteroid impacts, as well as explain why impact extinction events are so rare."

To understand the difference, consider some of the mechanisms triggered when

a large object from space hurtles into the Earth. An asteroid enters the atmosphere at extremely high speed, glowing red-hot as friction with the atmosphere turns it into a fiery cannon ball. Its impact with the ground results in a massive explosion, vaporising the space object and launching over a million million tonnes of gas, ash and rock dust into the atmosphere. If the asteroid is big enough - Pope says about three kilometers (two miles) in diameter - the energy released by the impact would hurl enough debris into space to envelop the Earth in a rain of fire. The ejected debris would re-enter the atmosphere like billions of meteorites, raining burning balls of fire back to Earth in a giant display of planetary fireworks. The brilliant glow from these billions of fireballs would ignite forest fires across the globe, generating vast, thick clouds of smoke and soot.

The asteroid that is associated with the mass extinction of the dinosaurs is believed to have been the one that created the Chicxulub crater in Yucatan, Mexico. It was certainly bigger than three kilometers across (more like ten to 15 kilometers or six to ten miles) and it would cause global fires. Another important factor is that the Yucatan was especially rich in sulfur-bearing rocks (calcium sulfate). The impact vaporised the sulfate rock and deposited billions of tons of sulfur dioxide gas in the atmosphere. Studies of volcanic eruptions have shown that this gas would convert to sulfuric acid clouds in the atmosphere, and that such clouds could remain in the atmosphere for years. These clouds may have initially been thick enough to shut down photosynthesis for a year, and perhaps they blocked the sun long enough (several years) to cause major global cooling. This mechanism helps explain why the impact was especially devastating.

The original theory, proposed by Luis Alvarez and his colleagues in 1980, is that asteroid dust from the Yucatan impact formed dense clouds that surrounded the Earth, obscuring the sun. The prolonged period of darkness that shrouded the planet caused the plants to die, breaking the food chain and starving the animals. Many of them, including the dinosaurs, died out. But now Pope is challenging this theory. Arguing in the February 2002 issue of *Geology* that the assumptions behind the asteroid dust theory are wrong, he says that the damage estimates from future asteroid impacts are also amiss.

Pope used a model to show how the large dust particles found in the K-T layer [the geological term for the layer of Earth that dates to the time of the asteroid impact associated with the mass extinction] could disperse to arrive at his conclusion. From the results of his test he extrapolated how the finer dust particles, the ones that were supposed to have surrounded the Earth and altered its climate, would have dispersed. He believes that the Yucatan impact could not

have produced enough dust particles of a size that it would take to shut down photosynthesis for any significant length of time and therefore the original extinction theory is not valid.

Instead, Pope believes it may have been sulfur gases produced from impacted rocks and soot from global fires that shut down photosynthesis and caused global cooling. The original studies of the clay layer found at the K-T boundary assumed much or this entire layer was derived from fine impact dust, he said. More recent studies of this layer have shown this not to be the case. Furthermore, earlier estimates were based on extrapolations of data from surface atomic bomb blasts, which had about 100 million times less energy than the Chicxulub impact. Extrapolation over eight orders of magnitude is risky business.

Pope, who was involved with the identification of the Chicxulub crater as the dinosaur killer in 1989-1990 when he worked at the NASA Ames Research Center, said that the current widely held theory suggests that the ash particles caused by the impact were so fine that they would have remained suspended in the air for a long time, making the Earth dark for an extended period. But his model indicated that not enough ash could have been generated to do that and that, in any event the ash would not have dispersed in that way. Most of the ash would have fallen rather quickly near the impact area, causing substantial regional damage but having less effect with increased distance from the site. "The implication is that asteroids of a smaller size— with a diameter of under three kilometers— would not necessarily have the dire consequences for the planet that is currently believed," Pope said. "They would cause heavy regional damage, but the ash fall-out would not be as great as previously believed."

Pope says some scientists have challenged his theory. "They say there may be some other extinction mechanisms that smaller impacts trigger besides dust. That may be true, but no one has done the detailed studies to back up such arguments."

Summary of story from *National Geographic News*, February 26, 2002.

Fossil of Dog-Size Horned Dinosaur Unearthed in China

Researchers have announced their discovery of a very distant cousin to *Triceratops,* the well-known three-horned dinosaur with a massive bony protrusion behind its skull. The discovery is an important piece in the evolutionary puzzle of the horned dinosaurs. Although they are considered one of the most diverse groups of dinosaurs, little is known about their early evolution.

Named *Liaoceratops yanzigouensis,* the newest find hails from the fossil-rich

Yixian Formation in northeast China. Its discoverers say the dog-size creature is the oldest, smallest, and most primitive of the neoceratopsians, one of the two main lineages of horned dinosaurs. "*Liaoceratops* gives us a great window on the early evolution of the group and tells us that *Triceratops* and its relatives evolved from very small Asian ceratopsians," said Peter Makovicky, a dinosaur curator at the Field Museum in Chicago and the co-discoverer of *Liaoceratops.*

The paleontologists, who reported the *Liaoceratops* discovery in the journal *Nature*, date the fossils to about 130 million years ago. This indicates that ceratopsians branched into the two main lineages of neoceratopsians and psittacosaurids (parrot-beaked dinosaurs) much earlier than previously believed.

Triceratops was the largest of the ceratopsians - some 30 feet (nine meters) long and weighing an estimated 14,000 pounds (6,350 kilograms). Three prominent horns and a large frill at the back of the skull are the distinguishing characteristics of *Triceratops.* Scientists do not know why ceratopsians of the Late Cretaceous (75 to 65 million years ago) evolved large horns and frills. Various people have suggested that these prominent features were used to attract mates, much like the horns of antelope; for defense; or to support large jaw muscles.

The discovery of *Liaoceratops* doesn't explain the reason for these distinguishing characteristics, but does indicate that all of the various evolutionary theories could be correct. *Liaoceratops* has two small horns - one below each eye that appears to be for display, said Makovicky. A small frill at the back of its skull, however, is marked by clear scars for the attachment of chewing muscles, he added. "It appears that the expanded and ornate frills and many of the horns of large, advanced ceratopsians evolved later in the history of this group as the animals became larger, although *Liaoceratops* shows the beginnings of these features," he said.

The paleontologists do not believe that *Liaoceratops* used its horns and frill as a defense mechanism. "It was probably preyed on by theropod [meat-eating] dinosaurs and perhaps crocodiles," said Mark Norell, a paleontologist at the American Museum of Natural History in New York and co-author of the study. Stubby horns and a small frill would have been of little use warding off such creatures. Rather, *Liaoceratops* likely relied on concealment and flight in the lush forests of the Yixian region for protection.

The discovery of *Liaoceratops* adds a few more pieces to the already complex puzzle of ceratopsian evolution. "On one hand, the discovery of *Liaoceratops* fills the morphological [form and structure of the animal] gap between the primitive

psittacosaurid and advanced neoceratops," said Xing Xu of the Institute of Vertebrate Paleontology & Paleoanthropology at the Chinese Academy of Sciences in Beijing and lead author of the study. "On the other hand, it introduced more homoplasies [body features acquired as a result of parallel evolution or convergence of species] and thus makes the early evolution of ceratopsian dinosaurs more complicated." Examination of the Liaoceratopsian fossils (one adult, one juvenile) indicates that while *Liaoceratops* shared many characteristics with the neoceratopsians, it also retains a number of characters of the more primitive psittacosaurids.

Xu said this suggests that the characteristics of horned dinosaurs evolved independently of each other and, in some cases, more gradually than was previously believed. "Basically, dinosaurian evolution is a complicated process and our knowledge about dinosaurs appears to be far from enough to completely understand this unusual group of animals," he said.

Summary of story from *National Geographic News*, March 22, 2002.

Arctic Redwood Fossils Are Clues to Ancient Climates

Axel Heiberg Island, at 82 degrees north and just a stone's throw from the North Pole, was once a great vacation spot—during the Eocene epoch, about 45 million years ago. Lush redwood forests, ferns, flowering plants, and a huge variety of animals, now extinct, once thrived there.

Hope Jahren, a geobiologist at Johns Hopkins University in Baltimore, Maryland, is using wood fossils from Axel Heiberg to discover prehistoric weather patterns that enabled this now bleak, cold, and dry desert to support such a rich array of life. "I've always been enraptured with the idea that the Earth can change so dramatically," said Jahren "The Earth today is very different compared to how it was millions of years ago."

During the Eocene epoch, Axel Heiberg and much of northern Siberia and Alaska were covered in temperate forests with redwood-like trees called *Metasequoias,* similar to those now seen in Northern California. The trees were between 30 and 40 meters tall (98 and 131 feet) and densely packed, providing a canopy for a plethora of ferns and flowers, said Jahren. The largest tree found had a diameter of three meters (ten feet). What remains of these ancient redwoods today is "rather extraordinary," said Jahren. These trees look like driftwood on the beach—they are dry and flaky, with almost no other alterations," said Jahren. Unlike these trees, ancient forests often become petrified through the steady infiltration of minerals over many years, which eventually replaces the wood

tissue with stone. Because the wood is unadulterated, the tissues hold a chemical record of weather patterns during the period the tree lived. Jahren studies carbon, hydrogen, oxygen, and nitrogen because these elements are taken from the soil, water, and air and incorporated into the tissue of plants and animals.

Jahren and her colleague Leonel Silveira Lobo Sternberg of the University of Miami in Coral Gables, Florida, are examining chemically different forms, or isotopes, of oxygen in these ancient redwoods to reveal weather patterns during the Eocene period. Oxygen that a plant uses, said Jahren, comes primarily from water. Determining the chemistry of that water could reveal exactly where it came from. Rain that arrives after traveling long distances over land has a very different chemical signature than rain that travels over the ocean or just very short distances, she explained. The researchers' analysis of the oxygen content of the wood revealed "a bizarre absence of oxygen 18, the heavy isotope," said Jahren. Water contains both oxygen 16, the more common and lighter isotope, and the more rare oxygen 18. The analysis suggests that the water contained almost exclusively oxygen 16. The study appeared in *GSA Today,* a publication of the Geological Society of America.

One way to get water with these characteristics, said Jahren, is for that water to have traveled large distances over land. As water travels over land, she explained, the heavier oxygen is removed as it rains. The only route allowing moisture laden air to travel thousands of kilometers over land before reaching Axel Heiberg would be across North America, possibly from the Gulf of Mexico, said Jahren. "This idea is compelling because it would supply water rich in oxygen 16 and supply warm air to this very northern region," warm enough to nurture a forest.

Jahren finds this model of water transport intriguing "because this weather pattern is radically different from today." Current weather systems over North America tend to travel from west to east. In the Eocene epoch, a much warmer period when the poles were free of ice, weather systems could shift from south to north, said Jahren. But there is another possible interpretation of Jahren's findings, cautioned Scott Wing, a paleontologist at the Smithsonian Institution in Washington, D.C.

"Water from snowfall also contains low quantities of oxygen 18, thus matching the water profile from the wood," he said. He suggested the possibility that snow, formed over the then ice-free Arctic Ocean, may have supplied the island with water. This would indicate that the northern regions were actually much colder than Jahren suggests.

"Isotope levels are very difficult to interpret, and there are lots of questions remaining," Wing said. If Axel Heiberg were actually colder, it would imply that animals such as alligators, which were known to live at these latitudes, as well as plants, must have been tolerant of the cold.

Whether Axel Heiberg actually received waters originating from equatorial regions is "still up for debate," said Wing. But there are other questions left to answer. "These forests had four months of daylight and four months of complete darkness. Finding trees that could survive under these conditions is as flabbergasting as finding humans that live underwater," said Jahren.

Uncovering ancient weather patterns provides greater understanding of how ecosystems work, opening a window into the Earth's capabilities. It also offers new ideas about the kind of conditions that plants and animals might be able to survive in.

Summary of story from *National Geographic Today,* March 26, 2002.

Giant Leap for Palaeontology

As the storm clouds gathered over Europe just before the First World War, Werner Janensch and Edwin Hennig, of the Natural History Museum of Berlin, had very different things on their mind. Their search for dinosaurs in Africa had culminated in one of the greatest palaeontological finds in the world, hundreds of tons of dinosaur skeletons that thrust Africa into the global forefront of dinosaur research.

The discovery was at Tendaguru, in Tanzania, and included a variety of dinosaurs. But the real icing on the cake was the complete skeleton of the then largest known animal to walk on Earth, the 80 tonne plant-eating sauropod dinosaur *Brachiosaurus.* Today, it is only exceeded in size by the 140 tonne *Ultrasaurus*, which could just be a fully-grown Brachiosaur.

Brachiosaurus roamed a land of conifer trees and coastal flood plains, about 150 million years ago, when Africa was still connected to North America. Consequently, one might expect that these monster dinosaurs would have left their footprints on these muddy ancient shores, information that could be vital in understanding the behaviour of these giants.

Thus, it was particularly disappointing that not a single footprint of *Brachiosaurus* was found in Tanzania. Indeed, not a single giant sauropod footprint had been found in the whole of sub-Saharan Africa. Not until now, that is. In a paper submitted to the international journal *Geology*, a team of researchers from

Zimbabwe, Ali Kaci Ahmed, Tim Broderick and Theagarten Lingham-Soliar, reported the first sub-Saharan footprints of giant sauropod dinosaurs, discovered in the Zambezi Valley. One of the footprints, close to a metre long and 22cm deep, caught in the afternoon sunlight looked so fresh it could have been made only hours before, and not 150 million years ago.

This must rank as one of the best preserved giant dinosaur footprints anywhere in the world. Previous identification of the bones of *Brachiosaurus* no more than 50km away, together with the great size of these footprints make it extremely likely that they belong to a Brachiosaurid-type dinosaur weighing 60-70 tonnes. But what is most remarkable with the footprint is the raised ridge surrounding the entire impression, exactly like the ridge surrounding a meteorite crater and clearly to do with considerable impact in both cases. The preservation of this kind of ridge is rare in even the best-preserved footprints seen in the USA and Australia.

Once the mud the footprints are in hardens, it has to be covered by another layer of mud to be preserved, and both layers, over millions of years, are converted into solid rock. For these footprints to see the light of day again severe erosion of the top layer by floodwaters and wind must take place - and it is the ridges around footprints that will be eroded first and quickest. It has to be caught at the very inception of the erosion process. This preservation gives a graphic picture of the tremendous forces generated as each foot of this giant dinosaur impacted with the ground (calculated at about 27, 000 pounds per square foot).

So great is the force that firm mud from much deeper down is forced up to the surface around the edges of the foot to create a reasonably durable ridge. A ridge of sloppier mud would collapse within hours or less. Although the Tendaguru Formation and the famous Morrison Formation of the USA show striking similarity in the presence of the giant sauropod *Brachiosaurus*, the most notable difference is the absence of skeletons (or footprints) of large theropod (carnivorous) dinosaurs at Tendaguru comparable to the Morrison *Allosaurus*.

Here, Zimbabwe comes into its own. Within a radius of 500m of the giant sauropod footprints were more than 100 footprints belonging to a large theropod calculated at about four metres tall, there were also five trackways within metres of each other, with compelling implications of group predatory behaviour. So close were some of these trackways that the tracks of different dinosaurs overlap while still retaining their individual clarity.

The Zambezi Valley dinosaurs are a huge jump ahead of those of Tendaguru. Zimbabwe, and southern Africa in general, must rank now as one of the key dinosaur localities in the world. Ichnology, the study of tracks and traces, is a

fascinating subject. It is also a beguiling subject as Winnie the Pooh discovered when he and piglet were tracking Woozles in the Hundred Acre Wood. It was only when Christopher Robin pointed it out that they realised that they were following their own footprints in circles. Poor Pooh sadly declared he was "a bear of very little brain." But Pooh would be pleased to know that ichnology is today a science at the top of dinosaur research, with much better data than was available to him.

Professor Theagarten Lingham-Soliar is in the Zoology Department, University of Durban-Westville. Dr Ali Kaci Ahmed is with the Zimbabwe Geological Survey and Tim Broderick is director of Jeremy Prince, Hydrologists, Harare, Zimbabwe.

Summary of story in *The Guardian* (UK), March 28, 2002.

Tree Climbing with Dinosaurs

A mouse-sized fossil from 125 million years ago is the earliest known member of the mammal group that includes humans say researchers. The animal is a primitive example of today's dominant mammals. "It's at the very root of this diverse and incredibly important group," says palaeontologist Zhe-Xi Luo of the Carnegie Museum of Natural History in Pittsburgh. Luo and his colleagues discovered the mammal, *Eomaia scansoria* (dawn-mother climber), in China.

The animal's elongated digits suggest that it was adept at climbing; this ability could have been used to escape from predators. Its skeleton is exceptionally well preserved, and the fossil shows its dense fur, most mammals of a similar vintage are known only by their teeth.

Eomaia's teeth and anklebones mark it out as a member of the group called the Eutheria, rather than a marsupial or one of the egg-laying group called monotremes. But *Eomaia* probably lacked a placenta, and would have reproduced in a similar way to modern marsupials. Its hips are too narrow to give birth to large young; its babies would have been born at an early stage of development and clung to their mother for shelter and nourishment. *Eomaia* was discovered in a fossil lakebed. When it lived, the surrounding landscape would have been lush and densely vegetated. The animal's teeth suggest that it ate insects, and it may have led a shrew-like life in bushes and trees.

The rocks that hold *Eomaia* are a fossil treasure trove, containing many beautifully preserved animals, including feathered dinosaurs. There are also other mammals, ranging from beasts smaller than *Eomaia* to a predator slightly larger than a domestic cat; these other species seem to have been less well adapted for climbing.

"What's so cool is that we're beginning to make some sense of how these animals lived together," says palaeontologist Anne Weil of Duke University in Durham, North Carolina. Although, she warns, reconstructing fossils' lives is "a bit of a guessing game".

Mammals were already a diverse group by this stage, adds palaeontologist Jerry Hooker of the Natural History Museum, London. "We must go back further to look for even older eutherians, to truly understand the evolution of early mammals," he says. Fossils suggest that there were seven mammal lineages present at *Eomaia's* time - our ancestors would have been "just another face in the crowd", says Weil, but only three of these groups survive today. Three died out while dinosaurs still roamed the Earth, the fourth about 35 million years ago.
Early marsupials - another lineage that survived and thrived - seem also to have been tree dwellers. An ability to climb might have given them, like *Eomaia*, the edge over their contemporaries, Weil suggests.

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Summary of story in *Science News Online*, April 25, 2002.

Dino Era Fossil - The First Flower?

From a bed of volcanic ash, deposited in northeastern China more than 124 million years ago, botanists have recovered impressively complete fossils of some of Earth's earliest flowering plants. The discovery of this new family of plants sheds light on the life and times of early members of an enormous category of flora, which includes flowers, trees, and many life-sustaining crops.

"Flowering plants are the dominant vegetation in the world today," says David Dilcher of the University of Florida in Gainesville, U.S.A, who is one of the new fossil's co-discoverers. "They're the basic food crop and fiber source for the world's population."

Dilcher and his five colleagues, including four Chinese researchers, found the fossil in a sand-colored slab of stone that they extracted from a fossil-rich rock formation northeast of Beijing. They dubbed the fossil species *Archaefructus liaoningensis* and *Archaefructus sinensis*. Together, the finds make up the family Archaefructaceae.

"When we study [Archaefructaceae], we're looking at the ancestry of what sustains us in the world today," says Dilcher. "It's useful for us to understand the relationships among flowering plants, especially in this day of molecular genetic

manipulations." The finding could also help scientists understand the evolutionary history of the flowering plants - where they began and how they gave rise to so many modern species.

Based on the age of the rock in which the fossils were found, the discoverers believe the plant lived at least 124.6 million years ago, during the dinosaur-dominated early Cretaceous Period, that age makes Archaefructaceae among the earliest of flowering plants. Pollen grains of even more ancient flowering plants, dated to about 130 million years ago, represent the oldest known evidence of flowering plants. Similarly aged fossils have been found of waterlilies, another type of flowering plant that persists today and, like Archaefructaceae, lived in the water.

The same fossil bed yielded evidence of similar flowering plants several years ago, but the fossil traces of the organism were much less complete, and Dilcher and his colleagues were forced to guess about certain characteristics. "These are the earliest, most complete remains of flowering plants yet discovered," Dilcher says. "What's spectacular about these fossils is that all parts of the plant are present, including the roots, leaves, and reproductive organs."

The nearly intact specimen enabled the researchers to determine that it grew in watery environments; it wouldn't have been able to support its own weight on land. The feather pattern of its leaves also indicates that the plant lived in water, Dilcher says, an observation that is further supported by the fossils of fish found in the same slab. It probably lived in a shallow lake populated by dinosaurs, crocodiles, turtles, and numerous types of fish.

Archaefructaceae's seeds are enclosed inside fruits, a characteristic that separates flowering plants from more primitive seed-producing plants, interestingly, however, petals - typical of many flowering plants - are absent. Given the quality of the fossil's preservation, they were not apparently lost during the process of fossilization. Instead, it seems, this plant never had petals.

The researchers analysed the fossil to determine where it fits into the evolutionary tree of the plants. By comparing the physical forms of related ancient and modern organisms, scientists can make educated guesses about which are most closely related and in what order various innovative features evolved. Based on their analysis, Dilcher and his colleagues conclude, in the May 3rd issue of the journal *Science,* Archaefructaceae was a sister family to all living flowering plants. This means that Archaefructaceae diverged from the flowering plants before the ancestor of all modern members of the group arose, making it as close to the original flowering plant as any fossil yet found. That raises the

possibility, says Dilcher that flowering plants actually evolved in aquatic environments, a scenario that runs counter to conventional wisdom.

Other scientists, however, say it's difficult to evaluate exactly where the new fossil fits in among flowers. Several suggest that the fossil may have been an early, petalless variation on the water lily - another aquatic, flowering plant - that ultimately went extinct. Even if there were two lineages of early flowering plants that were aquatic, says James A. Doyle of the University of California, Davis, U.S. A, "it would still be a pretty wild hypothesis to say flowers evolved in the water."

Summary of story in *National Geographic News*, May 3, 2002.

Oldest Worm Trail Discovered

Fossils in rocks thought to have been deposited 1.2 thousand million years ago could be the oldest evidence of animal life discovered so far.

Australian researchers believe a worm-like creature left a trail in sandstone found off the western tip of Australia. If confirmed, it would be the oldest example of an animal comprised of more than one cell. Until now, it was thought that multicellular animals, or metazoans, only appeared about 600 million years ago. The rocks in question come from the Stirling Range Formation of southwestern Australia. Fine ridges in the sandstone may be "casts of mucus-impregnated strings of sediment left by an organism creeping over the surface," say Dr Birger Rasmussen and colleagues of the University of Western Australia.

The fossilised worm cast gives a glimpse into a primordial world. This was a time when scientists believe the Earth was inhabited largely by microbes and algae. According to current theory, there was a sudden burst of animal life about 600 million years ago; this event - the Cambrian explosion - is clearly recorded in the fossil record. There is little undisputed evidence of animal life before then, so the Australian research could prove contentious.

If the dating studies are correct, scientists will have to explain why little changed on Earth for millions of years after the arrival of primitive animals. The fossil evidence is presented in the journal Science.

Summary of story in *BBC News Online*, 9 May 2002.

Comets May Have Led to Birth and Death of Dinosaur Era

Comets slamming into the Earth may be responsible for both the birth and the death of the dinosaur era, an international group of researchers report. There is a considerable amount of evidence that a bolide (a comet or asteroid) collision

with Earth triggered the end of the dinosaur era 65 million years ago.

An international team of scientists has assembled a compelling collection of evidence that a giant ball of ice, rock, and gas smashed into the supercontinent Pangaea 200 million years ago, ending the Triassic era and beginning the Jurassic. The impact was devastating to ocean life, and more than half of land-based species disappeared. Once the dust had cleared, dinosaurs began their 135 million year reign as the planet's dominant life form. "We have been able to show for the first time that the transition between Triassic life forms to Jurassic life forms occurred in a geological blink of an eye," said Paul Olsen, a geologist at the Lamont-Doherty Earth Observatory of Columbia University, U.S.A. "The change was associated with an iridium anomaly suggesting the cause was the result of a giant impact of an extraterrestrial body." Olsen is the lead author of the study published in the May 17, 2002 issue of the journal *Science*.

"Different lines of evidence, including dinosaur footprints, skeletal remains, and a spike in iridium levels exactly at the change in plant spores from the strata that mark the Triassic-Jurassic boundary, are all suggestive that a disaster befell the land and it may have been a comet or an asteroid," said Dennis V. Kent, a geologist at Rutgers University and a co-author of the study.

Since the first appearance of life on the planet around 3.6 billion years ago, there have been at least five mass extinction events, when 50 percent or more of the species on Earth disappeared. On the other side of these biodiversity crashes, new life forms appear and thrive. The mass extinction of the dinosaurs 65 million years ago, for instance, leads to the Age of Mammals. "The disappearance of one set of plants and animals, and the appearance of new forms of life, are what characterise geological boundaries," said co-author Hans-Dieter Sues, a paleobiologist at the Royal Ontario Museum in Canada.

The Earth was still one big landmass 200 million years ago, a supercontinent called Pangaea that was getting ready to break apart. As the Earth's crust stretched and thinned, great rift valleys appeared. One, called the Newark Basin, was formed just prior to the separation of North America from Europe and Africa. Stretching through parts of New York, New Jersey, and Pennsylvania, it is a geological treasure trove. The researchers examined footprints, bones, and plant spores at 70 locations in the Newark Basin. "The Triassic-Jurassic boundary is identified very precisely by a fern spike," said Dennis V. Kent. "An increase in the spores of ferns is indicative of an ecological calamity. Ferns are the first plant to invade and colonise when everything else has been wiped out. You can see a similar phenomenon today at Mt. St. Helens after the volcano erupted."

At the same strata of rock and ancient soil, the researchers found an increase in the abundance of iridium. Scientists don't know whether it was a comet or an asteroid that plowed into the Earth, but both contain iridium, and on impact, a layer of dust is laid down. New capabilities to measure at the parts-per-trillion level using high-resolution mass spectrometry enabled the researchers to identify a previously suspected but never found iridium spike. Just below the Triassic-Jurassic boundary, the scientists found a thin layer of sediment where the Earth's magnetic field is reversed; this reverse polarity happens at random intervals and is very useful to scientists in dating when events happened. Finally, just above the Triassic-Jurassic boundary, there are massive lava flows. It's possible that the explosive impact created by a comet collision triggers increased volcanism; there is evidence in India and Siberia of massive lava flows coincident with other extinction events. Scientists haven't been able to figure out the mechanisms by which this would occur - "it's another point of befuddlement," says Kent - but the fact that the phenomenon is seen at both the K-T boundary (Cretaceous-Tertiary Boundary, 65 million years ago) and the Permian-Triassic boundary (250 million years ago) is suggestive, he says.

"There are similarities to the K-T extinction," said Sues. "The fern spike indicating a significant ecosystem disruption, the disappearance of large groups of large land animals, higher concentrations of iridium. All these different pieces of evidence build a picture supporting the idea that a collision occurred."

"Most of the early mammals came through the extinction - turtles, frogs, salamanders, and of course dinosaurs. The dinosaur's major competitors were wiped out though, and they became the dominant life-form," says Sues. With many of the earlier life forms eliminated, the survivors no longer had to compete for food, water, and habitat. In some cases, their status shifted from prey to predator. The drop in competitive pressure may have triggered both the global spread of dinosaurs and their rapid increase in size. The researchers believe the rapid - a time scale of thousands of years - increase in size was an evolutionary response by the survivors, which may have been quite small prior to the extinction. The dinosaurs reigned supreme for 135 million years, until another comet colliding with Earth took them out. Once the dinosaurs were gone, mammals had the run of the land, and they flourished.

It may be time to take what we're learning about the Earth's history and apply it to our thinking about evolution and the role of natural selection, says Sues. "It shows these great mass extinctions are almost a lottery," he said. "The dinosaurs came through and flourished 200 million years ago, but when a similar event happened 65 million years ago they become extinct. It may well be

that catastrophic events have a far more profound effect in the shaping of life than people had previously thought."

Summary of story in *National Geographic News*, May 16, 2002.

Killer Cats Hunted Human Ancestors

Three South African scientists believe they have identified several predators that preyed upon human ancestors millions of years ago. The potential hominid killers include *Megantereon,* an extinct saber-toothed cat with oversize fangs, the leopard, and spotted hyena.

Archaeologists Julia Lee-Thorp and Nikolaas van der Merwe of the University of Cape Town, and paleontologist Francis Thackeray of the Transvaal Museum in Pretoria, South Africa, believe these carnivores were stalking and killing early hominids on the South African savanna 2.5 million years ago. The team's findings are based on a study of the chemical composition of the tooth enamel of several prehistoric carnivores. Tooth enamel is composed mostly of calcium and phosphate, but includes small amounts of carbon. Stable carbon isotope analysis involves tracing the changes in the ratios of two naturally occurring carbon isotopes - carbon 12 and carbon 13 - through the food chain. Carbon 13 concentrations are higher in grasses than in trees and shrubs.

"In ecosystems with a warm growing season, most grasses use a C4 pathway of photosynthesis that leaves them relatively enriched in C13," says Lee-Thorp. "Trees, shrubs and herbs follow a C3 pathway that discriminates strongly against C13. The carbon isotope signature of these two groups is therefore distinct." Farther along the food chain, the tissue and bone of animals that fed on grasses will also reflect more C13, while browsing animals that foraged on trees and shrubs show lower concentrations of C13. Predators also reflect the carbon isotope ratios of their prey. To identify possible hominid predators, the researchers first ascertained what the hominid species excavated at Swartkrans, a site situated in the Sterkfontein valley about 25 miles (40 kilometers) northwest of Johannesburg, South Africa, were eating.

"*Paranthropus robustus* and the early Homo species, *Homo ergaster,* had a diet that reflected a mix of carbon isotopes, suggesting that they were omnivorous, which is similar to what modern humans are today," said Lee-Thorp. Knowing the hominid carbon isotope ratios, Lee-Thorp and her colleagues were able to compare the ratios to those found in various carnivores found at the site. The team examined fossilized tooth enamel of leopards, lions, and spotted hyenas, in addition to three extinct species: *Megantereon; Dino felis,* a false saber-toothed cat; and *Chasmoporithetes nitidula,* an extinct hunting hyena.

The tooth enamel of the leopard, spotted hyena, and *Megantereon* drew a match, indicating that the individual specimens studied, at least, may have feasted on hominids. The findings were published in the *Journal of Human Evolution.* To most paleontologists, the leopard and spotted hyena have long been obvious predators of hominids; even today, the modern descendants of these flesh-eating mammals have been known to attack and devour humans, *Megantereon,* however, is a surprise to some scientists.

Bob Brain, a paleontologist who pioneered the investigation into hominid predators in his book *The Hunters or the Hunted?,* doesn't think that *Megantereon* fits the hominid killer profile. He believes their canine teeth would have caused little damage to a hominid skeleton. "Its long canines were too delicate and probably only effective in slicing up larger prey," Brain said. In his book, Brain suggested that *Dino felis,* the false saber-toothed cat, was a specialist primate killer, picking off hominids and baboons and then dragging them back to its cave lair. Lee-Thorp's research, on the other hand, seems to clear the false saber-toothed cat; its carbon isotope ratios suggest that it concentrated on grazing animals, filling a niche that modern lions occupy today.

Larry D. Martin, curator of vertebrate paleontology at the University of Kansas Natural History Museum, U.S.A, has no problem seeing *Megantereon* as a hominid killer. "Although *Megantereon* has large teeth, it is fairly small bodied and I doubt that it took larger prey than does the modern lion, which is a serious potential threat to modern hominids. I have no doubts that *Megantereon* would take a hominid whenever one might become available," he said.

Professor Phillip Tobias, emeritus professor of Anatomy and Human Biology at the University of the Witwatersrand, South Africa, believes Lee-Thorp's study has greatly enhanced scientific understanding of the diets of early hominids, apes, and that of some of the large carnivores. "For a long time this has been the object of much study; (Raymond) Dart first claimed that ape men hunted all other mammals, then C.K. (Bob) Brain determined through a series of brilliant analyses that it was primates that were the hunted and not the hunters. Now Lee-Thorp and her colleagues' research appears to provide proof that ape men were being hunted," Tobias says.

There is not enough isotopic evidence yet to absolutely convict any of these predators, and Lee-Thorp is looking forward to collecting more evidence at other dig sites. "Our study was limited to only a few specimens. It could be a case of where those individuals tested ate one thing while their peers concentrated on something else, only further testing will tell," she said.

Summary of story from *National Geographic News*, May 20, 2002.

Dinosaur Tracks Shed Light on Sauropod Evolution

Dinosaur tracks made on the edge of a coastal plain 163 million years ago in England are providing a team of researchers with new insights into the evolution and behavior of sauropods. Sauropods are the group of plant-eating dinosaurs distinguished by their long necks and tails. They include some of the largest creatures ever to walk on Earth.

An analysis of about 40 tracks of varying sizes indicates that they were made by a mixed herd of sauropods, concludes a group of researchers reporting in the May 31, 2002 issue of *Science*. One of the species represented in the tracks was a titanosaur, a dinosaur group that researchers didn't think had emerged for another 12 million years.

The tracks, which were found in a limestone quarry near Oxford, can be divided into two distinct types: those that have a wide gap between the left and right feet and those that have very little space, if any at all, between the left and right feet. Julia Day, a paleontologist at the University of Cambridge, England, and colleagues analysed these tracks to try and determine which species made them.

"Different groupings of dinosaurs are defined on the basis of unique characteristics. This can also be applied to the trackways," said Day. According to the researchers, each of the tracks contains characteristics that distinguish them as those made by sauropods. For example, the front footprints indicate the metacarpals - the hand bones on people - were held in a semicircular arrangement unique to sauropods. While there is not enough detail among the narrow tracks to enable the scientists to discern what species of sauropod made what track, the wide gauge tracks were clearly made by titanosaurs, the researchers conclude.

The wide tracks do not contain an impression of a claw on the front foot, whereas the narrow tracks do, as do another group of nearby tracks previously reported by Day's team to belong to theropod dinosaurs. Other researchers have shown that this claw is reduced in brachiosaurs, the sister group to titanosaurs. The claw is believed to be completely lost in titanosaurs. The absence of the claw in the tracks is thus not a sign that the tracks were poorly preserved, but rather corroborating evidence that the tracks were made by titanosaurs, the researchers note in their paper. "The titanosaurs are the only ones that make wide gauge tracks that don't have claw marks," said Day. "So we can be confident that they were made by titanosaurs."

The existence of titanosaurs at the quarry site 163 million years ago extends the

record of when titanosaurs diverged from other sauropods by at least 12 million years, according to the researchers. The earliest known skeletal remains of titanosaurs come from the Late Jurassic (154 to 144 million years ago) site of Tendaguru, Tanzania. Day hopes to confirm the earlier date for titanosaurs by finding fossilized bones in the limestone quarry where the tracks were found. "We don't have any osteological evidence at this site," she said. "We found these footprints. Now the next stage is to look for the bones."

Nearly all of the tracks at the quarry site point in a northeasterly roughly parallel direction. Day and her colleagues suggest this is an indication that the sauropods traveled in a herd. "Herding has been talked about before," said Day, who pointed out that evidence for herding has been reported from other track sites such as the Dinosaur Valley State Park site in Glen Rose, Texas, U.S.A. The difference, she said, is that there were at least two species of sauropods traveling together at the Oxfordshire site.

Geologic reconstructions conducted by Day's team indicate that in the time of the dinosaurs, the Oxfordshire site was a coastal plain 19 miles (30 kilometers) distant from the nearest landmass. The dinosaurs were walking directly where the sea meets the coast, so the tracks were probably left for only a few hours at a time between high tides. "What were these animals doing out there?" asks Day. She suggests it's possible that the sauropods were migrating between landmasses in search of food and formed a mixed herd to defend against predators.

Erik Kvale, a research geologist with Indiana University in Bloomington,U.S.A, who has studied dinosaur tracks in Wyoming, cautions against making any conclusion based on the interpretation of tracks alone. "It is very difficult to time the passage of a series of animals," he said. "I have watched gulls on a beach repeatedly circle an area in search of food. The net result is a series of tracks which can parallel a shoreline made by a single bird."

According to Kvale, the tracks could have been made by a single dinosaur, or perhaps by dinosaurs moving singularly in one direction along a geographically restricted pathway spaced out by minutes, hours, or days. "Their tracks may have nothing to do with migration but rather moving away from water or toward water or simply grazing or looking for food," he said.

The existence of theropod dinosaur tracks in the area, however, leaves Day speculating about why the sauropod herd might have been leaving the area and whether it was protecting itself against a threat. Theropods are the group of meat-eating dinosaurs that includes *Tyrannosaurs rex*. "It is an interesting site," said

Day. "Theropods were there and their trackways are all going in the same direction. The theropods might be tracking them."

Summary of story from *National Geographic News*, May 30, 2002.

Fossils of First Footsteps on Land Found in Ontario, Canada.

A set of fossil tracks in a quarry near Kingston, in southeastern Ontario, Canada, is causing scientists to re-think the timeline of when some creatures made their first brief forays onto land. Scientists say the fossilized footprints of an ancient, lobster-like arthropod came from an area that was once the shore of a huge sea stretching all the way to Texas.

A team of researchers led by a Canadian geologist think the creatures crawled out of the sea about 500 million years ago - that's tens of millions of years before scientists thought. The tracks are about 10 centimetres wide on average and the longest one, which is incomplete, is 2.5 metres long.

Dr. Robert MacNaughton of the Geological Survey of Canada is one of the scientists who discovered the tracks. He and his colleagues from Queen's University in Kingston, Ontario, Canada; the University of Bristol in the United Kingdom and the oil and gas company Nexen Canada of Calgary wrote about the discovery in a recent issue of the journal *Geology*.

MacNaughton said that based on a detailed study of the sandstone bed where the fossils were found; he thinks the creatures came out of the sea onto a barren, rocky land surface. "We know that animals came out of the sea (here) for the first recorded time," said MacNaughton's colleague, geologist Robert Dalrymple of Queen's University.

MacNaughton said the age of the fossils shows it may have taken animals much longer to migrate from the sea and adapt to life on land than previous models suggest. The tracks may show when sea life first survived on land, but other scientists say they don't pin down when the full-scale movement of life to land took place. "They may have had to retreat back to the sea for the rest of their lives and maybe only came out temporarily, sporadically," said David Rudkin of the Royal Ontario Museum.

Summary of story from *CBC News Online*, June 6, 2002.

Fossil Leaves Suggest Asteroid Killed Dinosaurs

A team of scientists says evidence from fossilized leaves indicates that dinosaurs appear to have become extinct as a result of the catastrophic impact of an

Fossil Leaves Suggest Asteroid Killed Dinosaurs

A team of scientists says evidence from fossilized leaves indicates that dinosaurs appear to have become extinct as a result of the catastrophic impact of an asteroid and not volcanic activity. Dinosaurs, along with an estimated 70 percent of all life on Earth, are believed to have gone extinct 65 million years ago as a result of a series of dramatic temperature changes. The extinctions are known as the K-T extinctions because they fall on the boundary between the Cretaceous (geological symbol K) and the Tertiary periods.

Some researchers believe that a burst of volcanic activity at the Deccan Traps in India is to blame for the climate changes, while others insist that fallout from an asteroid impact was the cause. Garland Upchurch, a biologist at Southwest Texas State University in San Marcos, Texas, U.S.A., and his colleagues analyzed fossilized leaves from gingko trees and ferns that grew about the time of the dinosaurs' demise to determine the state of the climate.

"The work on the fern and gingko leaves, when coupled with geochemical modeling, indicates that there was a mega-greenhouse effect after the terminal Cretaceous event and that this was most likely caused by an asteroid impact," said Upchurch. An analysis of the K-T boundary fossil leaf research, co-authored by Upchurch and scientists at the University of Sheffield, England, and Pennsylvania State University, U.S.A., appears in the June 11 *Proceedings of the National Academy of Sciences*.

Upchurch and his colleagues analyzed the fossil leaves to determine how much carbon dioxide was in the atmosphere about the time of the dinosaurs' demise. Atmospheric carbon dioxide is a greenhouse gas: increased levels of the gas can raise the warmth of Earth. "Leaf fossils can indicate the amount of carbon dioxide in the atmosphere because of the relationship between the frequency of breathing pores on the leaves - termed stomata - and levels of atmospheric carbon dioxide," said Upchurch. When there is more carbon dioxide in the atmosphere, leaves need fewer breathing pores to extract carbon dioxide from the atmosphere for photosynthesis. "This has been documented in a number of modern plants grown under controlled conditions at different levels of atmospheric CO_2," said Upchurch.

These controlled experiments have resulted in what scientists term the stomotal index, which shows an inverse relationship between the amount of carbon dioxide in the atmosphere and the number of breathing pores on the leaves. The researchers compared the fossilized fern and gingko leaves with a stomotal

index derived from the closest living relatives of the fossil plants, which allowed them to reconstruct past levels of atmospheric carbon dioxide for analysis. The analysis indicates a sudden and dramatic increase in carbon dioxide levels equivalent to injecting 6,400 billion metric tons of carbon into the atmosphere, which is enough carbon to warm the Earth by 12 degrees Fahrenheit (7.5 degrees Celsius).

"6,400 billion metric tons of carbon is, by at least a factor of five, more than the entire carbon pool of either modern or latest Cretaceous vegetation," said Upchurch. "If our calculations are correct, a significant quantity of the carbon had to come from the vaporization of limestone rock by the asteroid impact on the Yucatan Peninsula," he said.

According to the analysis of the leaf fossils, the increase in carbon occurred over a period of 10,000 to 20,000 years, too short of a time period to lay the blame on volcanism at Deccan Traps, which scientists have said lasted from 500,000 to several million years. Dewey McLean, emeritus professor of geology at Virginia Polytechnic University in Blacksburg, Virginia, U.S.A., who proposed the Deccan Traps volcano theory in 1981, said the fossil leaf database that Upchurch and colleagues used for their analysis is too small to accurately depict the timing of the K-T boundary record. "At one collecting site, they have one leaf," he said. "And for each of the other sites only a few leaves."

According to McLean's analysis of the Deccan Traps, 70 to 90 percent of the entire lava pile from the eruptions at the Deccan Traps began 65 million years ago, right at the K-T boundary. The *Proceedings of the National Academy of Sciences* paper does not change Dewey's belief that the Deccan Traps volcanism is the major culprit behind the global warming that led to the mass extinctions at the K-T boundary. "I believe that a number of factors combined to trigger a major K-T transition greenhouse, of which Deccan Traps was the primary contributing factor," he said.

Summary of story from *National Geographic News*, June 17, 2002.

'Oldest' Hard-shelled Fossil

Scientists have glimpsed the earliest days of sophisticated life on Earth. They have discovered the fossilised remains of a marine animal - perhaps a sponge or coral - which they say lived nearly 550 million years ago. The creature's hard, shelly parts are far more complex than anything else found from this time.

It gives researchers an insight into a period of Earth history just before life

on our planet are thought to have gone through many rapid changes. "This was a crucial time in evolution in terms of the fossil record," said Dr Rachel Wood, from Schlumberger Cambridge Research, UK. "It is when the light turned on, as it were. "It's when multi-celled animals started to get hard skeletons. This [organism] has a much more complex biomineralised shell than we've seen before. It's also very big - it can reach up to a metre."

Dr Wood and colleagues report their findings in the journal *Science*. They found their fossil organism in what remains of a giant reef in southern Namibia. The creature - classified as *Namapoikia reitogensis* - lived in the deep fissures or cracks in the reef. It is comprised of a series of tubules, each just a few millimetres in diameter. These hard parts are fully biomineralised; they are not leathery like the skeletons of other creatures from this time. If it was a coral, each tube would have probably housed a polyp with tentacles. If it was more like a sponge, its entire surface would have been covered in a thin veneer of tissue; small canals would have acted as a filtration unit to pull food out of the water.

The features displayed in the fossil have, until now, only been seen in specimens that are 15 million years younger. The primitive nature of *N. reitogensis* means it is impossible to say whether it is really a Poripheran (sponge) or Cnidarian (coral). "It's a characteristic of a lot of the Precambrian organisms that they share features of many groups," Dr Wood said. "They are what are known as stem groups. In other words, they haven't diverged into all the groups we know today."

Summary of story from *BBC News Online*, June 29, 2002.

Primeval Rainforest? Colorado Fossils Show Unexpected Diversity

The size, shape, and riotous variety of fossil leaves unearthed at a site in central Colorado suggest that the region may have been covered, some 64 million years ago, with one of the world's first tropical rain forests.

Excavations at a site about 50 meters off Highway I-25 near the town of Castle Rock, Colorado, U.S.A., have yielded the remains of two species of conifers, three types of ferns, six types of fruits, and 90 species of broad-leaved flowering trees. The diverse assemblage of fossils consists primarily of fallen leaves that were suddenly buried by a 25-centimeter-thick flood of mud about 1.4 million years after the demise of the dinosaurs, says Kirk R. Johnson of the Denver Museum of Nature & Science, Colorado, U.S.A. He and museum volunteer Beth Ellis described the find in the June 28, 2002 issue of *Science*.

Mathematical relationships between the climate in which a modern forest grows

and the size, shape, and variety of leaves on its trees, enabled Johnson and Ellis to infer conditions at the site when the ancient forest thrived. The leaves among the ancient forest's species were large - about 67 square centimeters on average when mature. This leaf size suggests the site received about 225 cm of rain annually, enough to qualify as a rain forest, Johnson says.

About 69 percent of the plant species there had smooth-edged leaves, which hints that the forest had an average temperature of just over 22°C, or about the same as modern Miami. Of the 48 species in which the ends of the leaves were preserved in fossil remains, 19 showed abruptly tapered tips, yet another clue that rain was abundant. Leaves with smooth edges and these so-called drip tips shed raindrops particularly well. Most species that prospered in earlier forest ecosystems didn't have these features.

Johnson says that most of the precipitation at the site came from humid winds that shed their moisture as they cooled while ascending the eastern slopes of the early Rockies. At the time, those peaks may have towered around 3,000 m over sea levels of the Gulf of Mexico, which then stretched into the central United States, and the Cannonball Sea, a long-gone arm of the Arctic Ocean that extended south to where North Dakota is today.

The multitude of tree species found at the Colorado site more closely resembles the diversity found in modern rain forests than the relative monotony found in deciduous woodlands of temperate regions. Also, the variety is surprising because hundreds of other sites dated up to 9 million years later typically preserve only a few species at each locale, says Johnson. Only later, during a worldwide warm spell about 52 million years ago, did widespread reblossoming of ecosystems take place, he notes.

Johnson and Ellis' survey of plants at the Colorado site is "an excellent and sizable census," says Leo J. Hickey, a paleobotanist at Yale University. They've found an unusual and unexpected set of plants for that time and place, he notes. The unique ecosystem may document a short spike in global temperature lasting less than 100,000 years, says Hickey.

Summary of story from *Science News Online*, June 29, 2002.

New Fossil: Link Between Fish and Land Animals?

What creature first crawled out of the prehistoric swamps to conquer the land? The question has long puzzled paleontologists because the transitional species seems to have lived during a mysterious 30-million-year gap in the fossil record called Romer's Gap.

Now a researcher in Britain has found a very rare fossil of a short, squat crocodile-like creature that she believes provides a stepping stone between our aquatic ancestors and the first four-legged land dwellers. "This really is one of a kind," said Jennifer Clack, a paleontologist at the University Museum of Zoology Cambridge, United Kingdom. "It may even be the first five-toed foot," she added, "but I can't swear to that yet."

The creature, named *Pederpes finneyae* probably came from a shallow-water environment - a lagoon or coastal flat - that was vulnerable to sudden increases in salinity as water levels rose and fell. Romer believed such an environment would have favored the evolution of limbs enabling land travel, to allow the animal a broader area to feed. Clack feels that the early evolution of hands and feet occurred in relationship to strictly aquatic locomotion, somewhat in the manner of seals.

The fossil was originally discovered in 1971 in a stream valley that cuts through moorland about three kilometers from Dumbarton, Scotland, and lay incorrectly classified in the Hunterian Museum, in Glasgow. The skeleton is almost complete, just missing a tail, and is thought to date back to 348 to 344 million years ago - the heart of Romer's Gap. The Gap is named for Alfred Sherwood Romer, an American paleontologist and a prolific writer of textbooks in the 1950s and 1960s, who first recognized the lack of fossils from this 30-million-year period.

The hint that *Pederpes finneyae,* might provide a missing link between the swimmers and the landlubbers lies in the bone structure of the hind leg. During the late Devonian period, about 365 million years ago, tetrapods had paddle-like feet for swimming that pointed back or to the side, said Clack. But *Pederpes* feet are different. *"Pederpes* looks as if its feet have been reoriented to point forward - perfect for locomotion on land," said Clack. That is, the middle toe on each foot points straight ahead just as is does in modern tetrapods like dogs, mice, and humans.

The late Devonian period has a rich fossil history of lobed fishes, the earliest four-legged specimens like *Acanthostega* and *Ichthyostega* lived about 363 million years ago. *Acanthostega* had limbs and eight digits on each hand and foot, and also had fish characteristics like gills, fins, and sensory organs that only worked underwater. But these fishy animals probably rarely left the water, said Per Ahlberg, a paleontologist of fossil fish and amphibians at the Natural History Museum in London.

After the Devonian the fossil record disappears, at least for a while, 20 - 30

million years. Only three informative fossils dating back to this time have been found. When the fossil record resumes roughly 25 million years later, there was already a tremendous variety of tetrapod landforms. Ancestors of modern mammals, amphibians, reptiles, and birds had already evolved and were diverging along distinct branches.

And that left questions. "We lack a focus from which all modern tetrapods evolved," said Robert Carroll, Professor of zoology, curator of vertebrate paleontology at Montreal's McGill University. "Romer's Gap is a 30-million-year black box that, frankly, keeps me up at night." Clack's latest find may help scientists sleep better. *Pederpes* will be particularly useful for the purpose of "reciprocal illumination," said John Bolt, curator of fossil amphibians and reptiles at The Field Museum in Chicago. "Seeing a new complete skeleton adjusts our mindsets to see new features in fossils that have already been examined. Otherwise we often see only what we expect to see."

The *Pederpes* fossil was originally misclassified as a rhizodont - an extinct type of lobed fish with the equivalent of upper arm and leg bones. In the mid-1990s, Clack's graduate student, perusing the collection at the Hunterian Museum noticed the fossil, basically a lump of rock with a few teeth protruding and brought it back to Cambridge for further study. "When I saw the rock I became excited. I could see some scales covering the belly which were quite unlike fish scales," Clack said. "I also noticed another protruding bone called the ischium and I became very excited because I knew that this was not a fish but a tetrapod."

Clack sent spore samples from the rock to a laboratory and found that the fossil dated back to approximately 350 million years ago. Working for four years, painstakingly chipping away at the rock under a microscope, Clack uncovered the well-preserved skeleton of *Pederpes*.

Clack says she has returned to the region where the fossil was found to scour the area for more specimens, but none have been found. *Pederpes* may have been short-lived, or we just may not be looking in the right places to find more. Who knows what other creatures may crawl out of Romer's Gap? The discovery is published in the July 4, 2002 issue of the journal *Nature*.

Summary of story in *National Geographic Today*, July 3, 2002.

Australian Cave Yields Animal Fossil Treasures

A team of amateur spelunkers has discovered caves filled with very well preserved fossils of giant flat-faced kangaroos, marsupial lions, wombats, Tasmanian tigers, and other megafauna that lived in Australia during the

Pleistocene era, between 1.75 million and 10,000 years ago. Paleontologists who have been investigating the cave, which is in a remote region of Australia's Nullarbor Plains in the state of Western Australia, have called it "the find of the century."

"A find like this comes along once in a lifetime, if you are lucky," said Gavin Prideaux, curator of the Naracoorte Caves collection at Flinders University in Adelaide and an expert on the Pleistocene cave fossils. "It was actually a pretty strange situation because with the first one, two, three specimens you feel you are over the moon with excitement, but everywhere we turned we found more material."

One of the most exciting discoveries is the first complete skeleton of a flesh-eating marsupial "lion," *Thylacoleo carnifex,* said John Long, curator of vertebrate paleontology at the Western Australian Museum in Perth, who led the three-week expedition, dubbed Operation Leo, at the site. To date eight skeletons of *Thylacoleo* have been found in these caves. "After finding the sixth, seventh, eighth specimen, it's overwhelming and exhausting to maintain excitement," added Prideaux. "It becomes, 'Oh wow, here is another perfectly preserved and complete skeleton of a *Thylacoleo.*' *Thylacoleo* is not a lion; it is more closely related to koalas and kangaroos. It is the largest carnivorous mammal ever to have lived in Australia and the largest known marsupial carnivore in the world.

At about two meters long, it was about the same size as a leopard, with massive paws and forearms, huge retractable claws, and enormous "opposable thumb-like" appendages that were probably used for tree climbing. Unlike the large cats that have two enlarged canines, marsupial lions had enlarged incisors that were used to stab prey.

Also among the caves' bounty are skeletons of up to 10 different species of extinct kangaroos; about 75 percent of the skeletons are complete, including three from giant kangaroos that were as tall as three meters (10 feet). There are also remains of the flat-faced giant kangaroo *Procoptodon goliah,* the largest of all kangaroo species. Another juicy find is the fossil of a giant wombat the size of a small car.

The structure of the Australian cave suggests it worked as a pit trap. The hole leading to the cave was covered with vegetation, said Long, and animals fell in and got trapped. Entering the cave today requires wriggling through a 10-meter-long (32-foot-long) tunnel that runs from the ground surface to the roof of the cave. Then there is a 15-meter (50-foot) drop to the cave floor.

Even with the precipitous drop, Prideaux believes most of the giant animals that fell into the cave didn't die on impact. "It looks like they didn't die for a few days because each specimen was found curled up in a different nook," he said. "They probably walked around and eventually died of starvation and dehydration." If the animals had died on impact, all the bones would have been found in a heap directly below the hole in the ceiling.

The paleontologists said the site is unique in part because of the distribution of the skeletons in three caves. Fossil deposits from the Pleistocene era are usually a jumble of sediment-embedded bones from different skeletons, Long explained. Such piles are created as rain or floodwaters gush through the caves, washing the dirt and bones into a corner. Sorting though piles of bones to distinguish various extinct species, some of them perhaps unknown, can be extremely difficult, he said. "Here the bones are completely undisturbed," said Long. "It is as if the animals just curled up in a corner and never woke up." The cave was probably sealed with dirt because there are no human remains or bones from any modern species.

The bones are in such good condition that Long collected DNA samples from several specimens, which he hopes to use to accurately date the remains, the DNA will also be used to establish evolutionary links to modern marsupials in Australia today.

The Nullarbor Plains - a vast, arid plateau stretching from South Australia to Western Australia and bigger than the state of Texas - are riddled with thousands of caves, but very few contain fossils. Even fewer have the dark, dry conditions necessary for preserving remains. "Thus we have a very poor paleontological record of the flora and fauna from this area, until now," said Long. "This cave is one of the most important megafauna sites in the whole of Australia and offers a snapshot of the diverse collection of animals that existed during the Pleistocene period."

Father Ken Boland of St. Francis' Church in Melbourne, Victoria, discovered the cave. An avid caver and pilot, he was conducting a survey of landscape features from his ultralight aircraft. Noting details such as soil color changes, holes, depressions, and fissures, he noticed an interesting feature and sent a ground team to explore. The ground team - members of the Australian Speleologial Federation - entered the cave for an initial investigation, and then withdrew without removing any of the fossil remains. The exact location of the cave is being kept a secret to protect it from looting by fossil hunters seeking specimens to sell on the black market.

Summary of story from *National Geographic Today*, July 31, 2002.

Fossil Find Proves New Zealand Once Had Snakes

Scientists have struck a fossil bonanza in Central Otago, including the first proof New Zealand once had snakes. That is, it had snakes 15 to 20 million years ago during the geological time period known as the Miocene age.

Tiny jaw and tooth fragments of a python-like snake have been excavated among new fossils of birds, fish, reptiles, and mammals. "The find is the first evidence of a land snake existing in this country and proves these reptiles once lived here," Museum of New Zealand Te Papa spokeswoman Vicki Connor said. "This is significant because it had long been thought New Zealand did not have snakes."

Te Papa, Institute of Geological and Nuclear Sciences, South Australia Museum, and moa expert Trevor Worthy combined forces in the project. Their findings were presented at the International Palaeontological Congress in Sydney, July 2002. Institute collections manager Craig Jones said that in Miocene-age New Zealand, freshwater deposits survived only in isolated pockets. The site - a rare occurrence of rock strata from the edge of a lake - is being kept secret.

"We don't want amateurs coming in and mining it, thinking they are going to find entire snakes," Jones said. He predicted that the discovery was "going to open up a whole new story in New Zealand fossil history." Among the new finds are three teeth and two scales of a crocodile-like reptile, thought to be 1.5 meters (five feet) to two meters (6.5 feet) long, and teeth of a tuatara-like reptile. Until now, the oldest fossil tuatara found in New Zealand are only 20,000 to 30,000 years old. Tuataras are large spiny four-legged reptiles found on islands off the coast of New Zealand.

The treasure trove also includes remains, only a few millimeters in size, of five species of pre-historic duck and goose, songbirds, a weka-like bird, a parrot, a bat, and fish species, Jones said. A lot more work would be needed to build up pictures of what these animals looked like, as all of them are new to science, eggshell fragments included possible moa eggs, he said. If confirmed, they would show moa ancestors were large and flightless at that time.

Summary of story from *National Geographic Today*, August 9, 2002.

Tiny Tyrant - Fossil May Be Mini *T. Rex* Cousin

Paleontologists from a small museum in Rockford, Illinois, have found what they believe to be the skeleton of the tiny tyrant *Nanotyrannus* - a smaller, faster but equally ferocious meat-eating relative of *Tyrannosaurus rex*. The only known

evidence of this dinosaur is a single specimen, a skull, which resides in the Cleveland Museum of Natural History, U.S.A. But the Cleveland skull has been the focus of controversy; some believe it is *Nanotyrannus,* a new genus of dinosaur, while others claim it is a juvenile *T. rex,* which has never been found.

"I'm 100 percent sure that what we have here is *Nanotyrannus,"* said Michael Henderson, curator of Earth Science at the Burpee Museum of Natural History in Rockford, Illinois, U.S.A. "When we saw the teeth we knew exactly what we had."

Based on the skull and a collection of teeth gathered from Montana, South Dakota, and Wyoming, Henderson and his colleagues believe that the teeth of *Nanotyrannus* are slim and razor-like for slicing through flesh. *T. rex,* by contrast, has teeth like railroad spikes - larger and rounder for piercing and puncturing prey and biting through bones. Furthermore, the new specimen is definitely not a juvenile, said Henderson, who led the expedition into the southeastern corner of Montana where the dinosaur was discovered. "It has a couple of fused vertebrae and the three pelvic bones are fused into one bone, which would only occur in an adult," he said.

The specimen, named "Jane" for a major donor to the Burpee Museum, is thought to have lived sometime between 68 and 65 million years ago - just before the mass extinction that wiped out the dinosaurs. She looks to be about 22 feet long and her long, narrow shin and anklebones suggest that she was "the cheetah of the Cretaceous," said Robert Bakker, who first described *Nanotyrannus* in 1988 together with co-authors Phil Currie and Mike Williams.

Jane was actually discovered in June 2001 by volunteer dinosaur hunters Bill Harrison and Carol Tuck while on a prospecting expedition led by Henderson in Montana's Badlands. They discovered a six-inch-long toe jutting out of the base of a 20 foot (6 meter) cliff face. From here they noticed a cross section of a lower limb, and lower down, a foot and pelvis, which implied that there was a significant portion of the skeleton within the cliff. Henderson marked the site, removed the toe and foot bone, and returned nearly one year later in May 2002 with permits, shovels, and volunteers.

"Until about two weeks ago we had no idea what we had found," said Joe Peterson, a junior at Southern Illinois University at Carbondale and an assistant to Henderson. A broken bone with a hollow space inside indicated that the creature was a carnivore, but yielded few other clues. When the toe was compared to specimens at the Black Hills Museum of Natural History in Hill City, South Dakota, last year, the team suspected that they had found *Struthiomimus,* an ostrich-like carnivorous dinosaur from the late Cretaceous Period that was a

tremendously fast runner. But as soon as the groups began to excavate and the lower jaw became visible, Henderson said, "we knew" it was *Nanotyrannus*. At present most of the skeleton remains embedded in an enormous slab of rock.

Henderson has removed enough sediment to reveal between 80 and 90 bones in the stone slab. Based on an adult *T. rex* skeleton he believes he has at least one-third of the full skeleton, including major bones - half the tail, ribs, vertebrae, the upper arm, the lower jaw with teeth, foot, leg, and skull. "This is one of the great finds of the century," said Peter Larson, director of the Black Hills Institute of Geological Research, Inc., in Rapid City, South Dakota, U.S.A. Larson gained notoriety after his discovery of "Sue," the largest and most well preserved *T. rex* fossil found to date. "Even the bones that are used to determine the sex of the dinosaur are present," he added.

"I feel like I've won the lottery. People have been looking for this for a very long time," Henderson said. "This dinosaur has been a mystery for more than 150 years," said Bakker. "A tooth was found in the 1880s, a leg around 1900, a skull in the 1940s, and just a few years ago more teeth. This thing has been a huge mystery." Henderson's excitement was buoyed by the fact that such extensive finds in the Hell Creek Formation of Montana are rare. The reason: The band of sediment where Jane was buried was from a floodplain where gushing waters 65 million years ago dispersed the bones of dead dinosaurs before they could be encapsulated and buried under protective sediments.

Thomas Carr, a graduate student at the University of Toronto now completing his dissertation, disputes whether *Nanotyrannus* exists. Using an analysis of growth changes seen in the skull of a well-known Tyrannosaurid called *Albertosaurus* for comparison, Carr reasoned that the Cleveland skull belonged to a juvenile *T. rex*. His research, a master's thesis, was published as the cover story in the September 1999 issue of the *Journal of Vertebrate Paleontology*. The narrow snout, wide braincase, and skull growth patterns all suggested to Carr that the Cleveland skull belonged to a juvenile. People seem to be very dismissive of the fact that this could be a juvenile *T. rex,* said Carr. "This is the only window on the growth and development of the most famous dinosaur in history - it is worth its weight in gold."

At least one year of work remains before the bones are released from the stone bonds. Only then will scientists really be able to assess whether this is truly a new genus. "The significance of this find is really that we expect this specimen to give us the answer and settle the debate," said Henderson. "But if this turns out to be a juvenile *T. rex,* then we will know that the youngster was quite different to the adult."

Summary of story from *National Geographic Today*, August 9, 2002.